Using NASA Data and Models to Improve Heat Watch/Warning Systems for Decision Support

Health and Air Quality Applications Program Review

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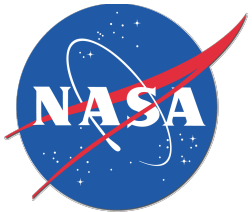
September 25, 2013



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Filtering of Mortality from Analog EHE's

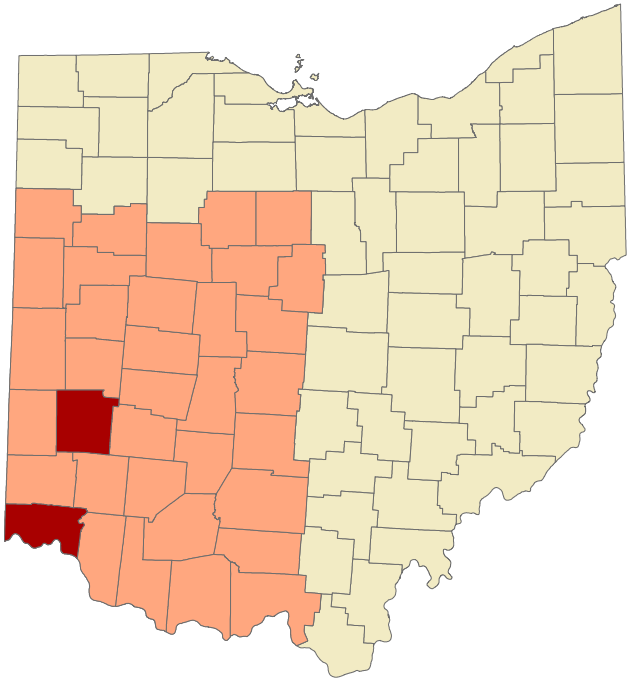
- Mortality data collected for all our cities
  - All geocoded for each study area and incorporated into models
  - Issues with data
  - Do not have data from this past summer yet (in negotiation)

Current Heat Health Alert Systems: Overview of Deficiencies

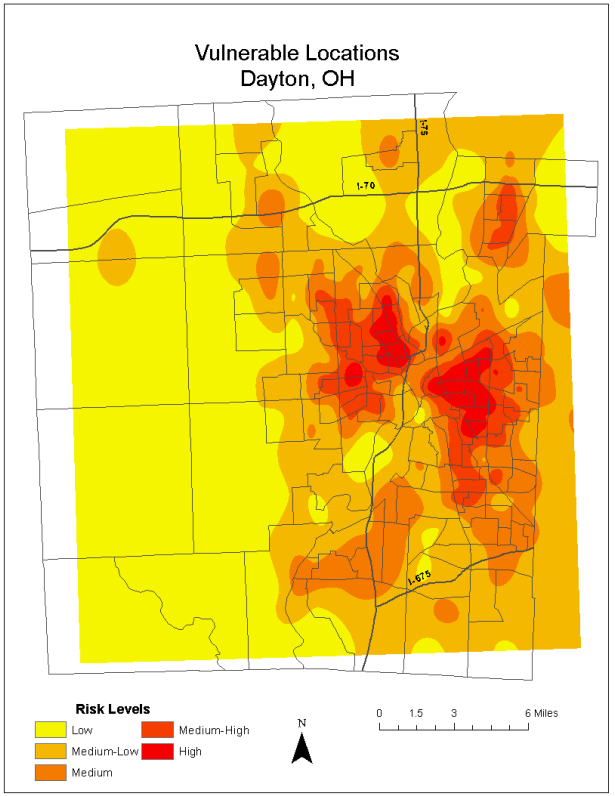
- Much of the deficiency has to do with spatial specificity. Where are the vulnerable? Where are the "hot spots"? Both thermal and health-related.
- "Current protocols for issuing heat alerts using synoptic weather models are very good".
  - Current research is beginning to reconsider this statement (cf: Matte, 2010)

Spatial Specificity in Heat-Related Warnings: The Past and the Future

Current Systems



Developing Systems



The “Discontinuous” UHI

The Micro-UHI Effect (Dayton)

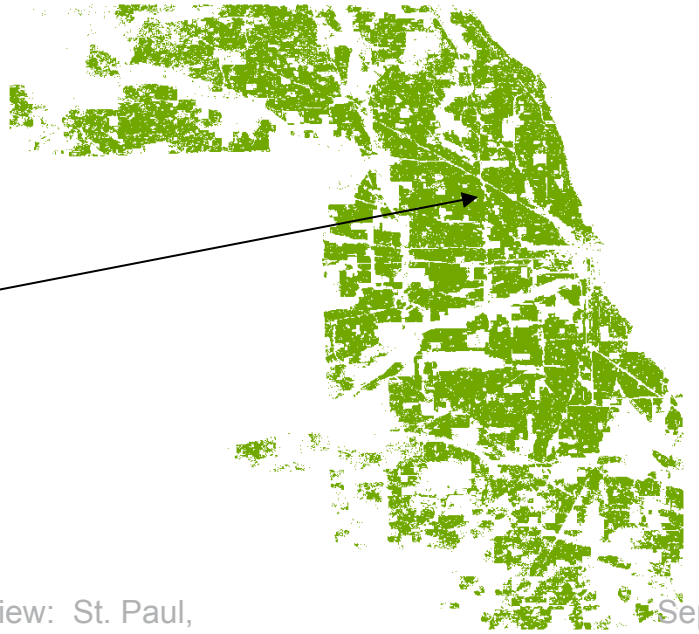
Important Data Considerations

- Currently exploring downscaling MODIS to Landsat ETM+, TM, or Landsat 8 resolutions. Having varying levels of success…
- This will give us the ability to provide daily guidance to each city; something that our end-users have requested.
- Re-calibrate on each “good” Landsat or ASTER if we can find it available or task the sensor?
- New sensors for this work???

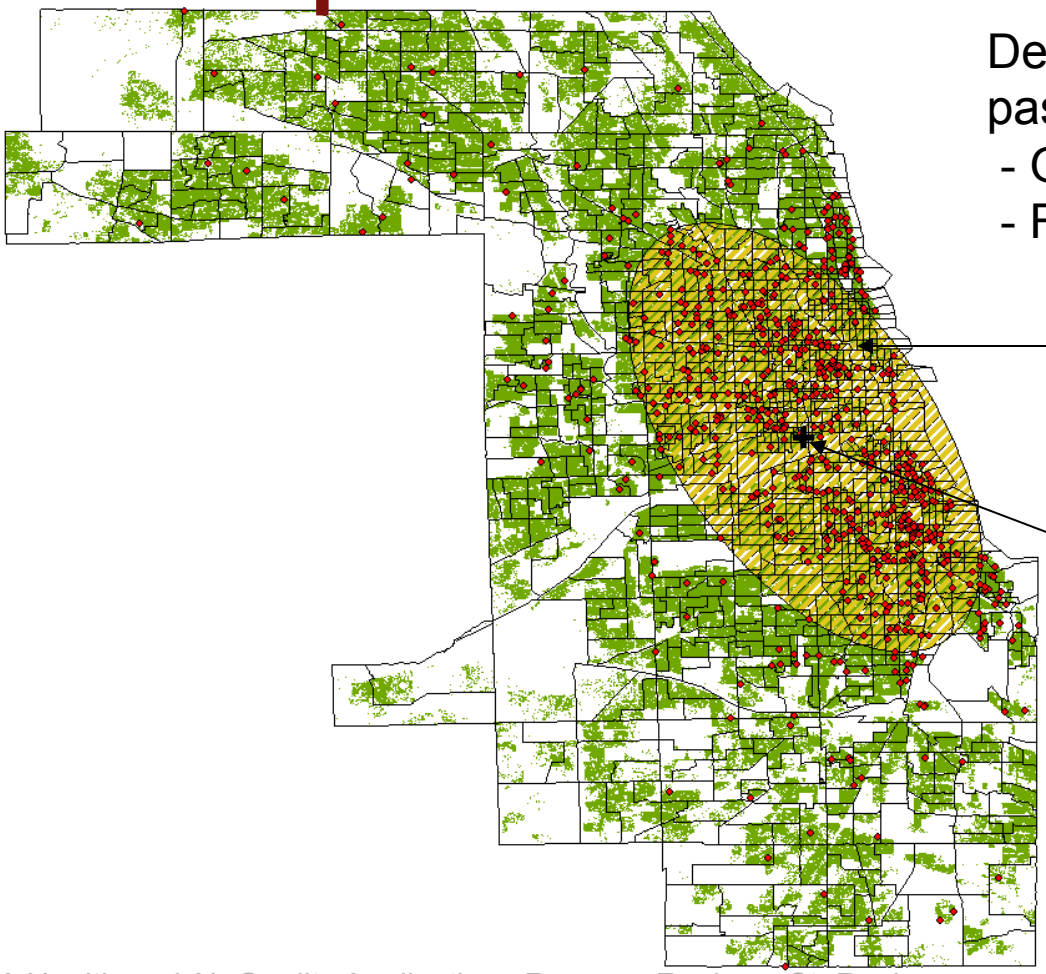
Important Data Considerations

- Use census socioeconomic data at the census tract/block group level
  - -Minority populations, lower income, lower educational attainment, and aged population
  - -Extract residential land use for population density calculation

Population Density Calculated by ***Area*** of Residential Land Use



Important Data Considerations



Death certificates collected for past analog events

- Geocode locations of mortality
- Further explore spatial distribution

1 SDE for Mortality

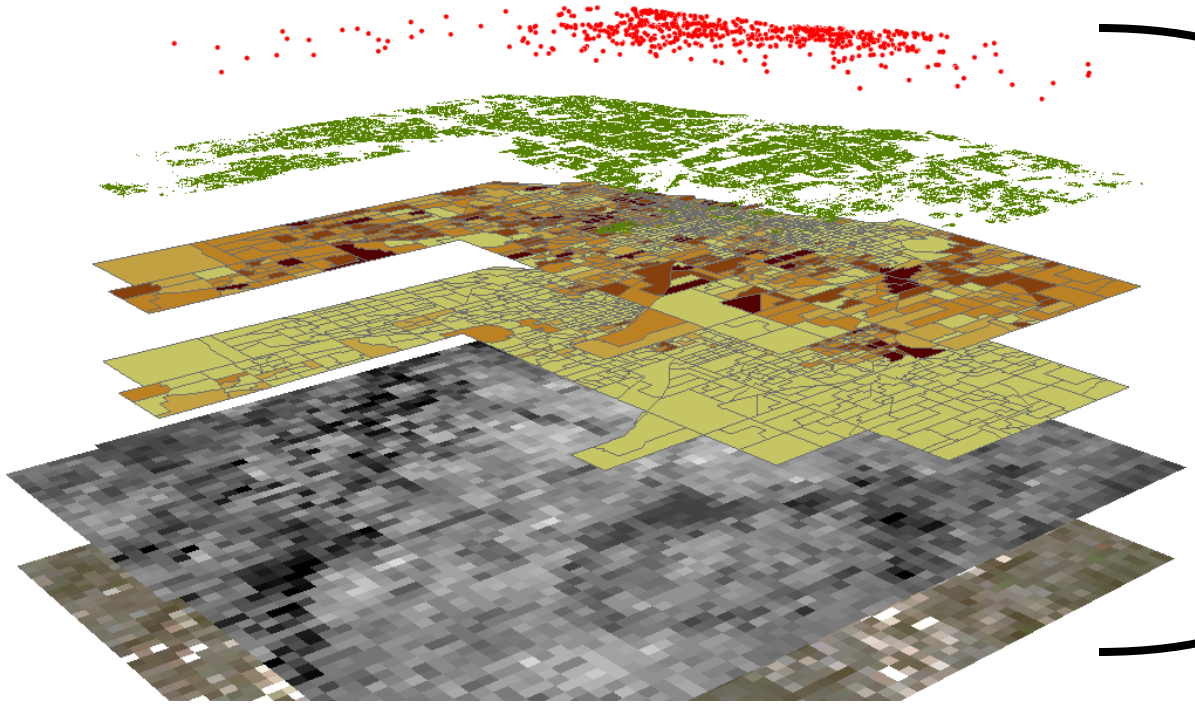
Mean Center of Mortality

Mortalities have been randomly offset by 50-100 meters.

Issues with Census 2010 data

- Slowed implementation
- 2010 data that is useful for our project was very late in becoming available 2011 and in some cases 2012.
- Different variables for a few of the vulnerability indicators
- We will need to concatenate a few variables to overcome the discrepancies in the decadal census

Developing the Extreme Heat Vulnerability Index (EHVI)



Risk to Extreme Heat is Hyper-dimensional

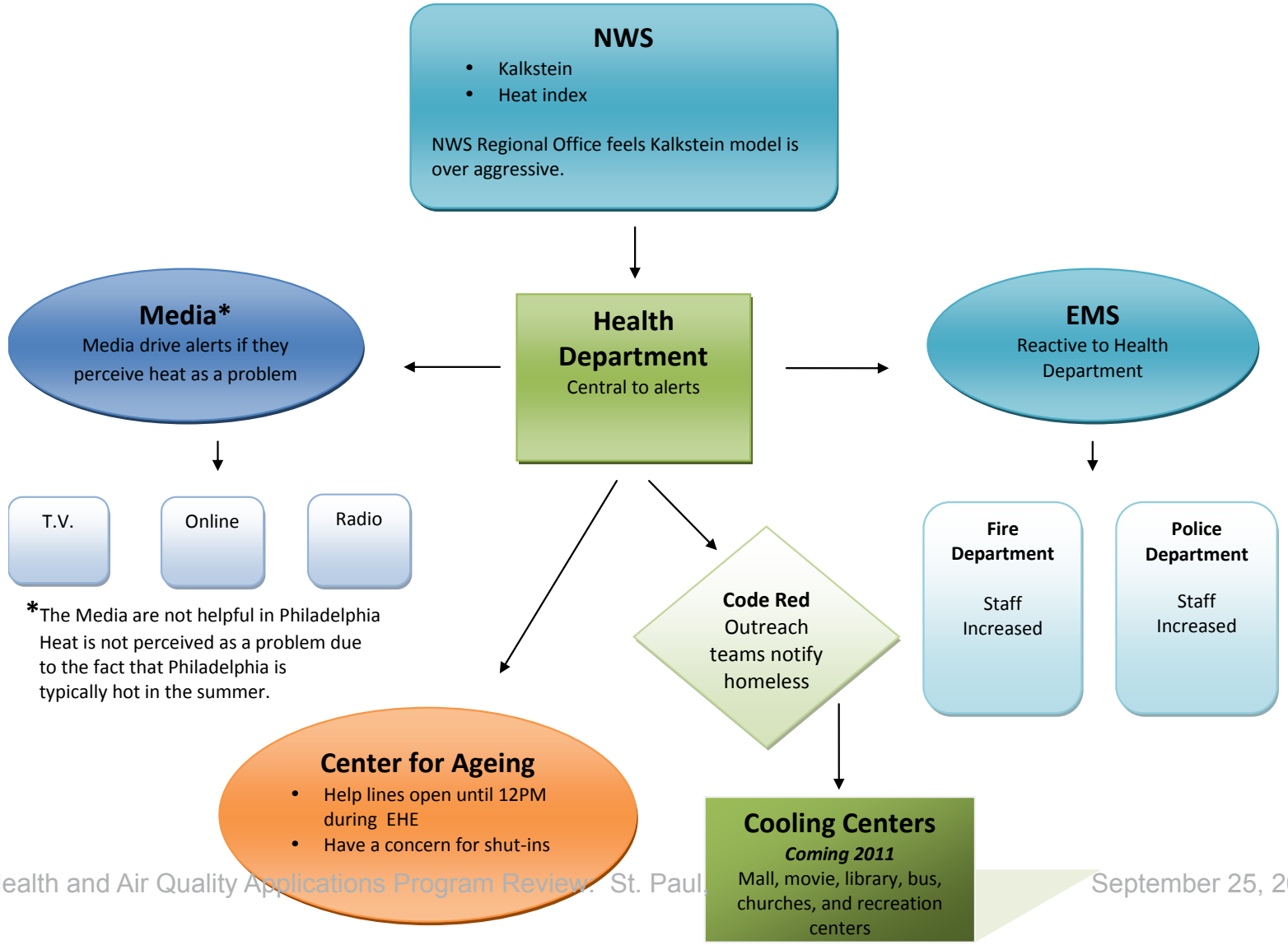
Community Outreach

- Series of focus groups for each city with appropriate organizations/personnel were conducted in Fall of 2010
  - Dayton
  - Phoenix
  - Philadelphia

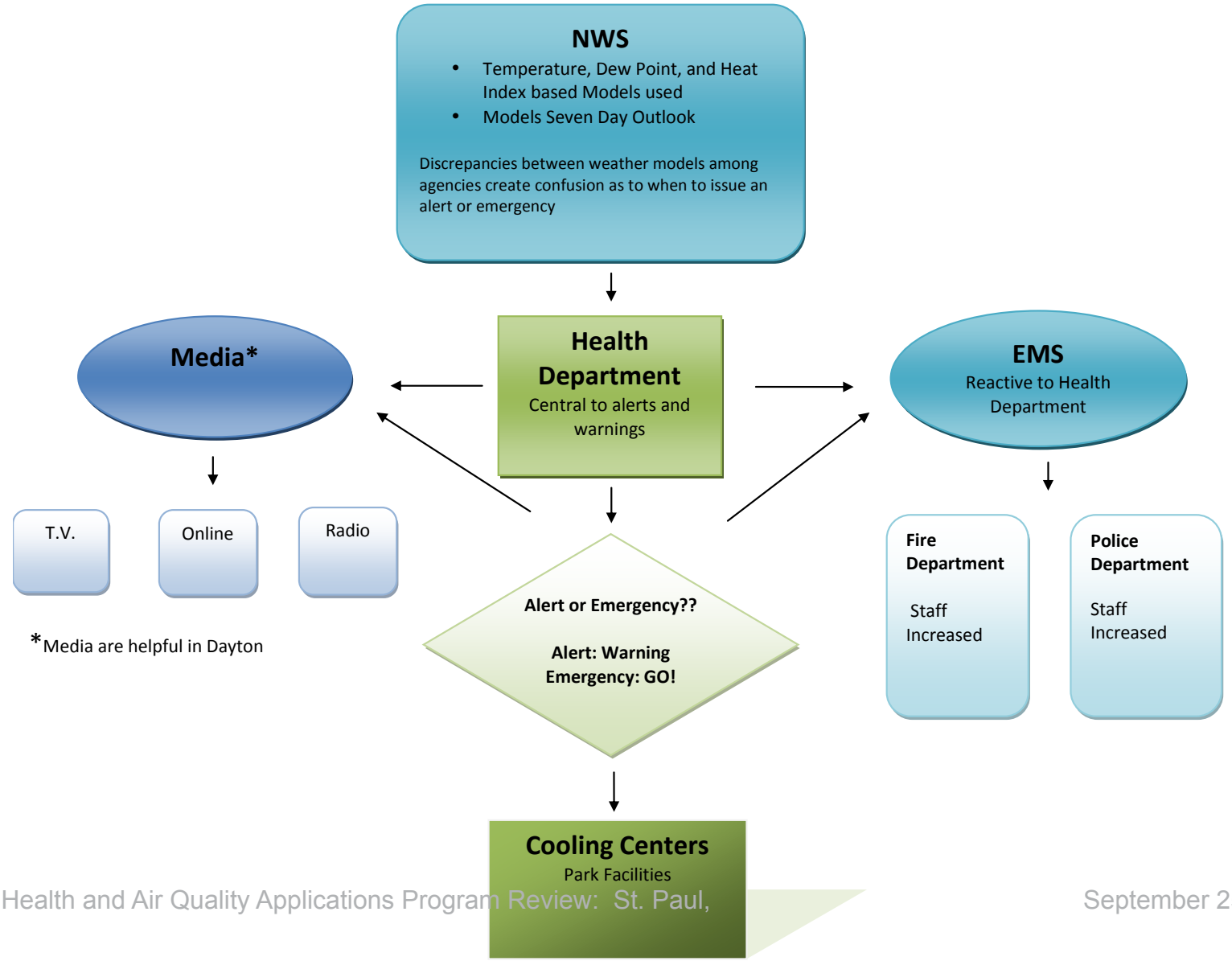
Community Outreach

- Dayton: 7 agencies / 18 participants
- Phoenix: 5 agencies / 15 participants
- Philadelphia: 5 agencies / 18 participants

Philadelphia Response Flow Chart



Dayton Response Flow Chart



Model Development

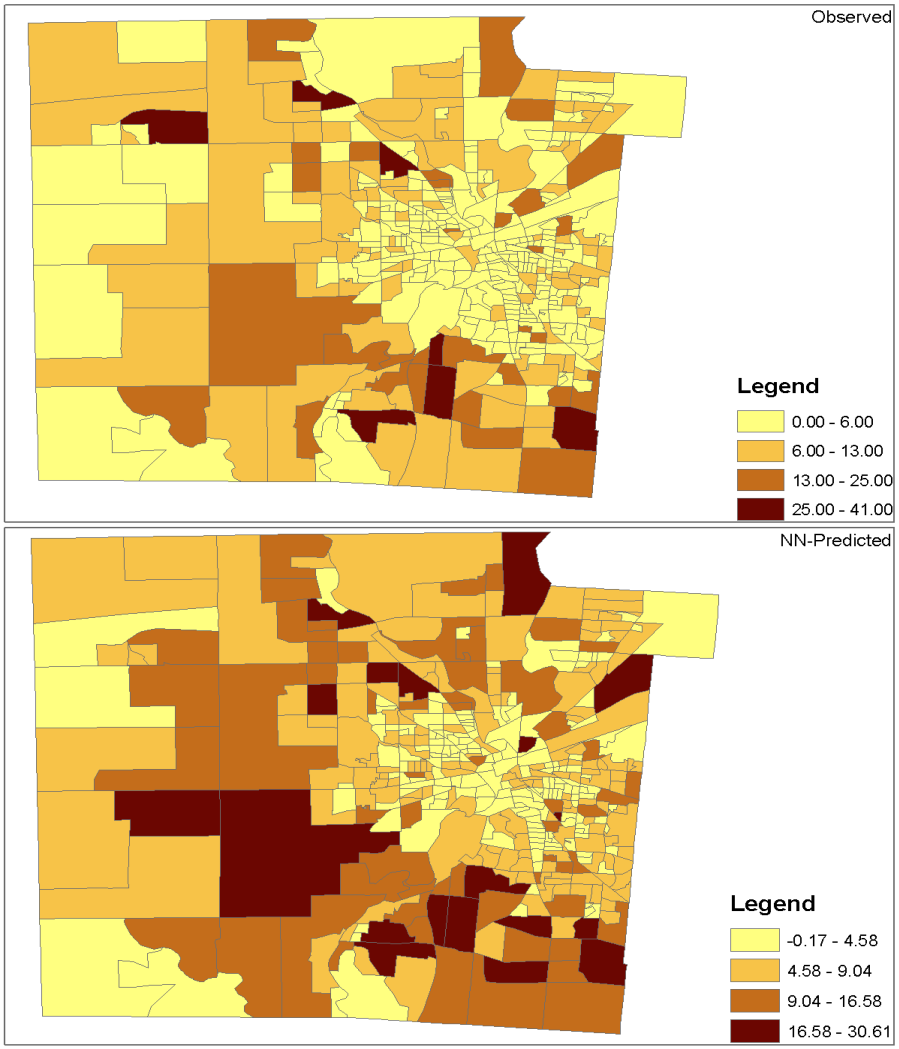
UPDATE ON ACTIVITIES FOR PAST YEAR

EHVI Tested with Neural Networks

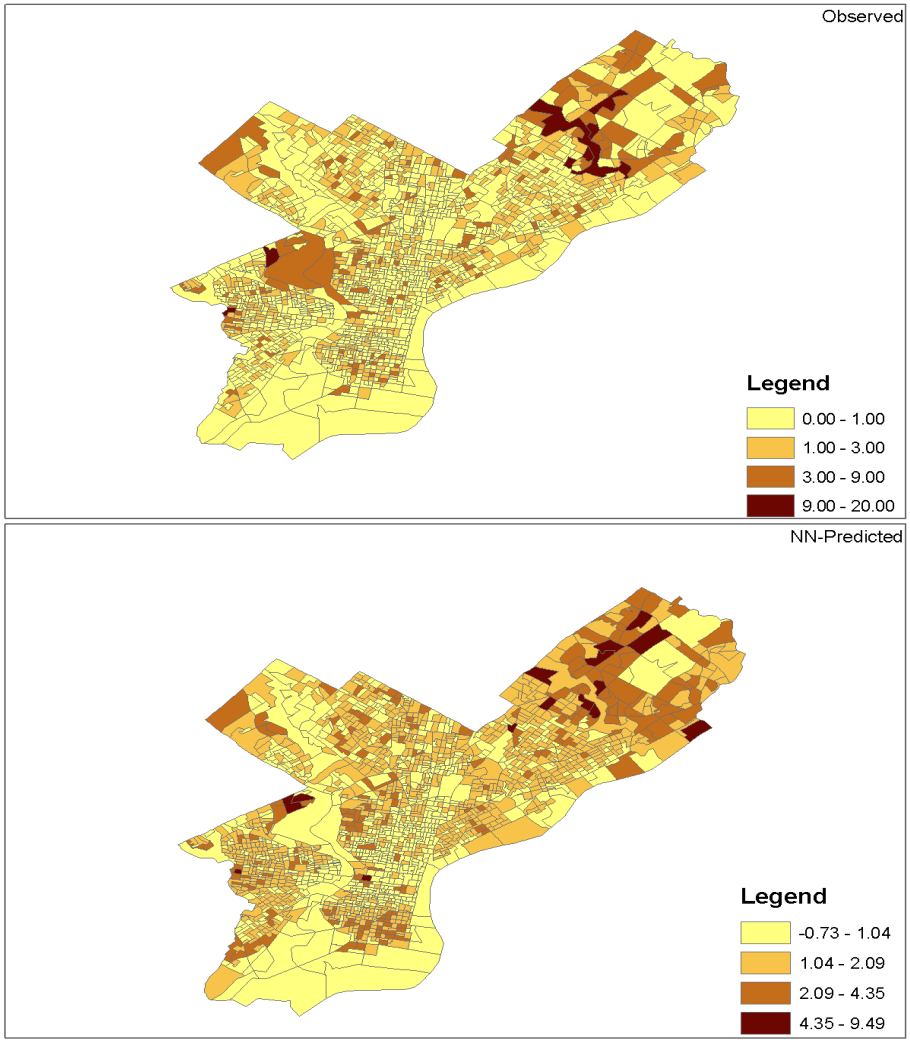
- All outputs from 12-3-1 Multilayer Perceptron (MLP)†
- Different architectures need to be tried.
  - With different number of hidden nodes.
  - With different input variables.
  - Combination of both?
- Different networks/techniques we are experimenting with currently.
  - Self Organizing Maps (SOM)
  - Empirical Bayes

† Modern Applied Statistics with S (2002) by W. N. Venables and B. D. Ripley

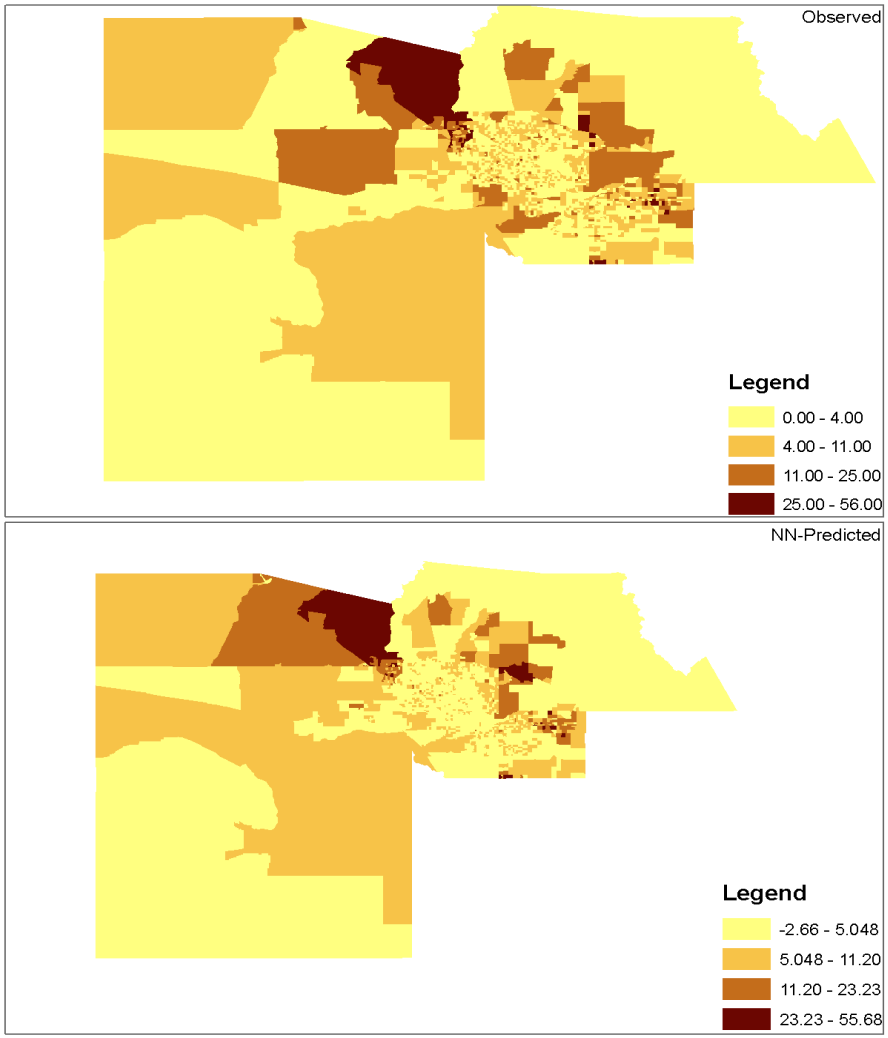
DAYTON (Block Groups)



PHILADELPHIA (Block Groups)



PHOENIX (Block Groups)



System and Interface Development

WEB-BASED SPATIAL DECISION SUPPORT SYSTEM

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Navigation

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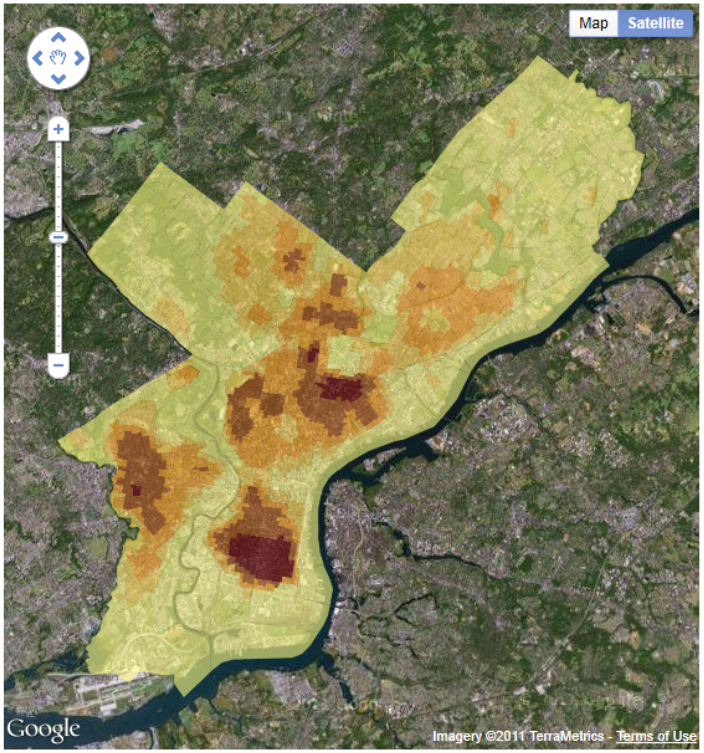
Philadelphia

Some more info about Philadelphia heat waves!



User login

Username *

Password *

- Request new password

Log in

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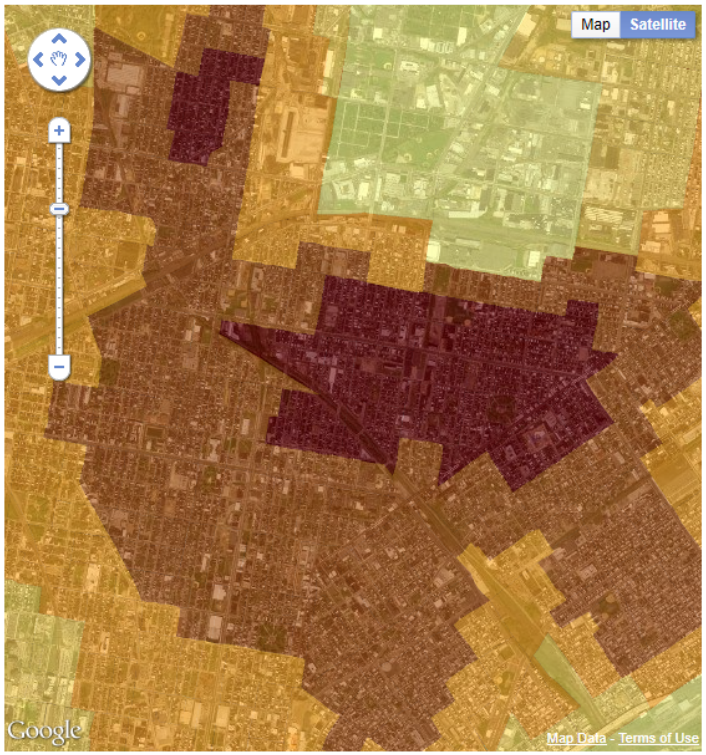

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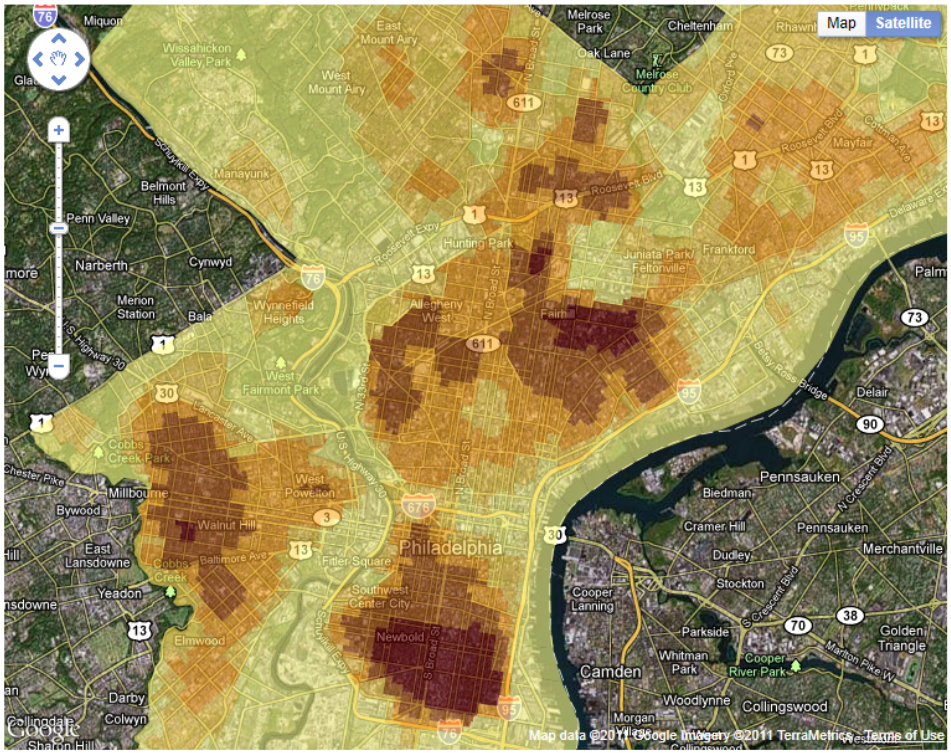
Some more info about Philadelphia heat waves!



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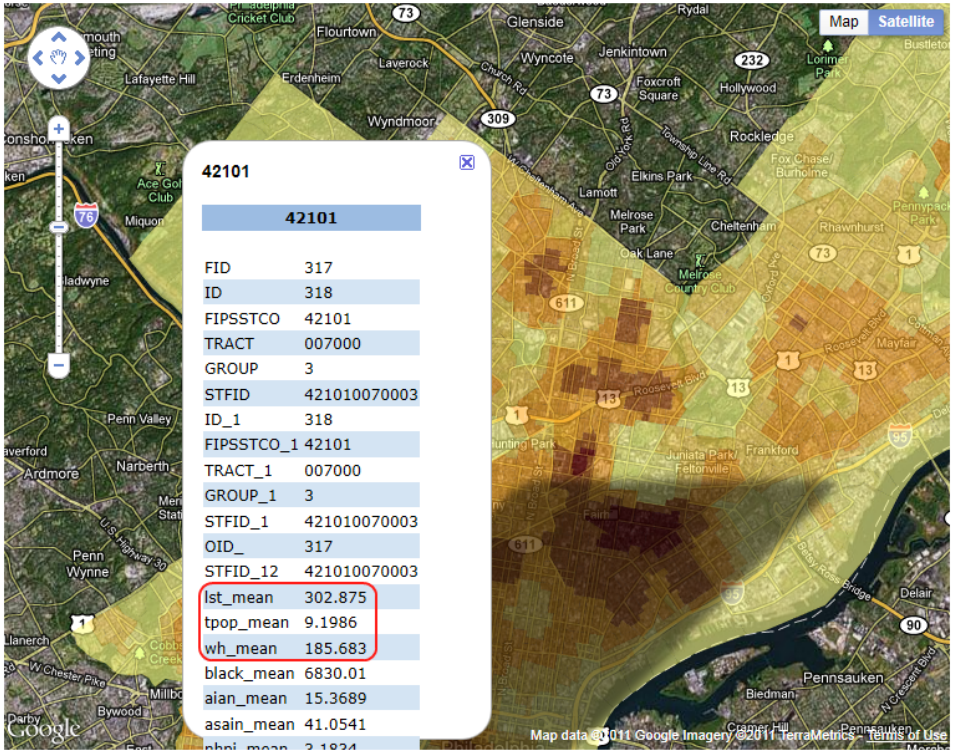

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INDIANA UNIVERSITY

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

INDIANA UNIVERSITY

Philadelphia

Geography Department of IUPU

Professor. Johnson, Daniel P.

You can use SHIFT + Mouse to zoom in and SHIFT + CTRL + Mouse to zoom out.

Layer List :

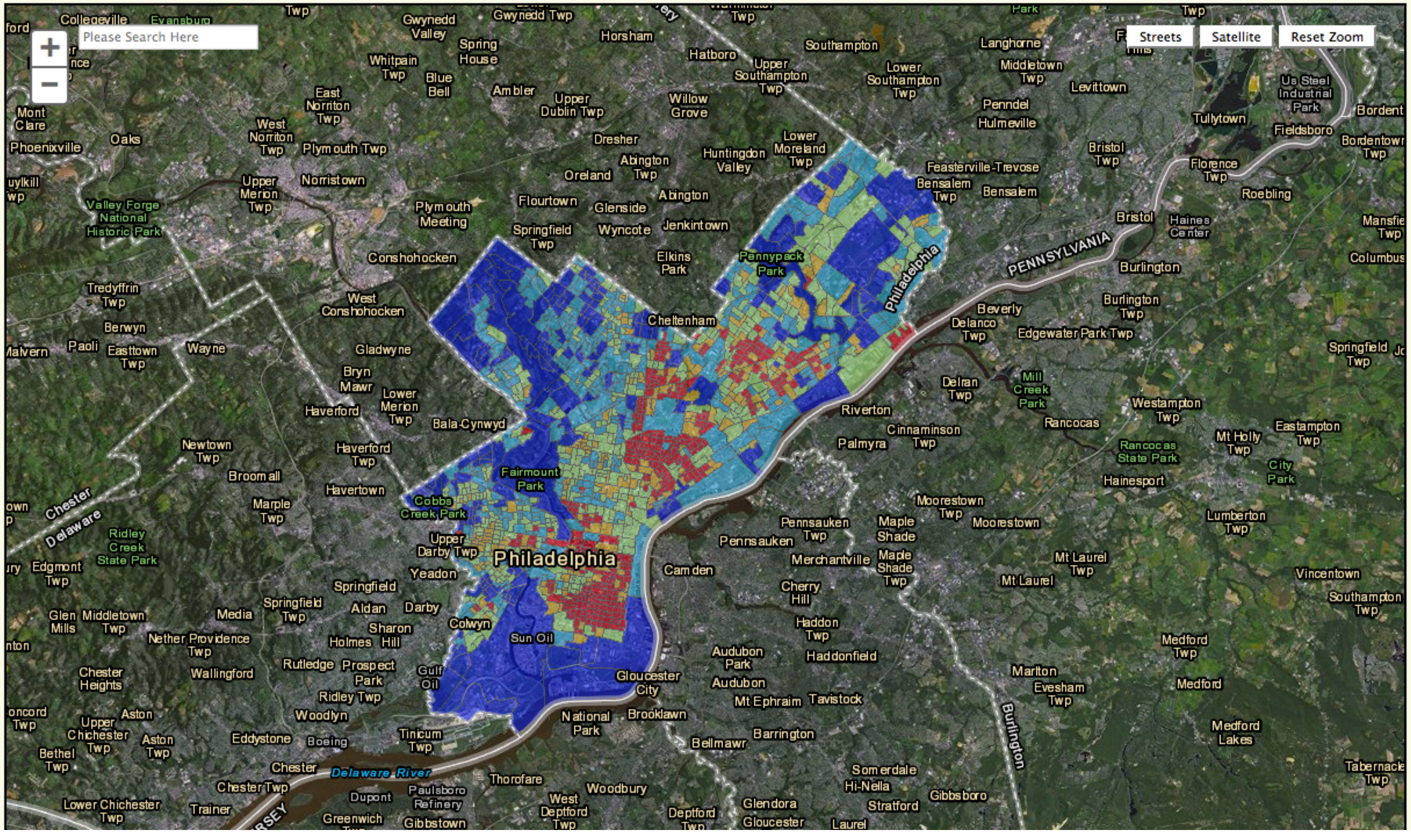
- ☐ Extreme Heat Vulnerability
- ☐ LST
- ☐ Pop Density

Opacity 50%

Refresh

Map Index

Add File



Philidelphia_2010

Extreme Heat Vulnerability Std. Dev.

- -5.829100 - -2.000000
- -1.999999 - -1.000000
- -0.999999 - 0.000000
- 0.000001 - 1.000000
- 1.000001 - 22.540100

LST_Mean

- Low
- Low - Medium
- Medium
- Medium - High
- High

Pop_Den

- Low
- Low - Medium
- Medium
- Medium - High
- High

Philidelphia_2010

Extreme Heat Vulnerability Std. Dev.

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LST_Mean

- Low
- Low - Medium
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Pop_Den

- Low
- Low - Medium
- Medium
- Medium - High
- High

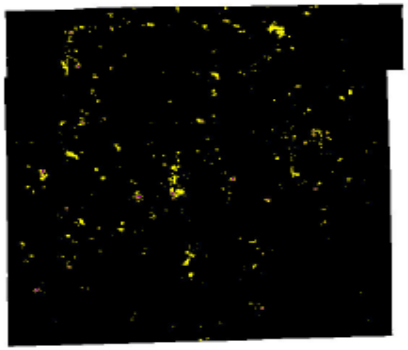
The temporal issue with our current model

DOWNSCALING

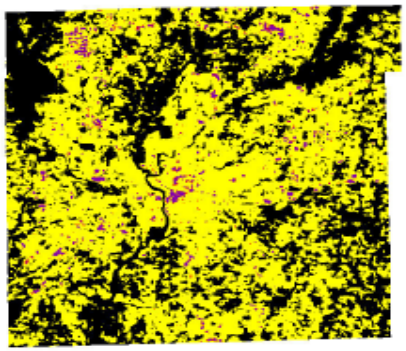
Indianapolis
Extreme Heat Events, 2010

06 March 2010

09 May 2010



25 May 2010



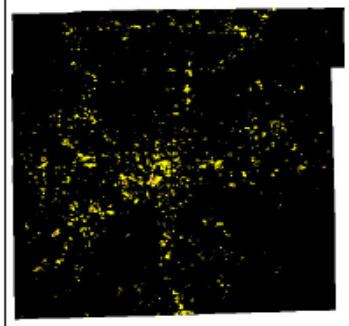
Percentiles

- < 90th
- 90th
- 95th
- 97th

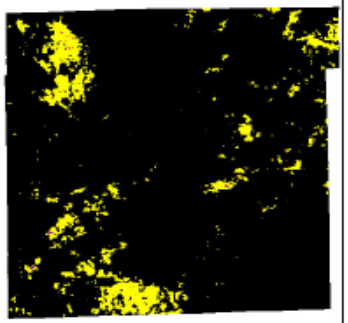
0 1.5 3 6 9 12 Miles

Indianapolis
Extreme Heat Events, 2011

10 April 2011



12 May 2011

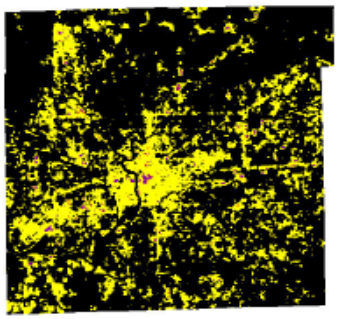


Percentiles

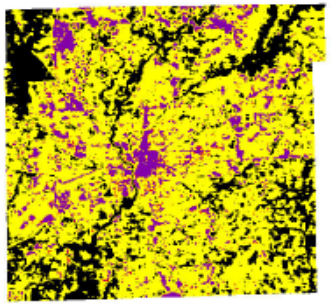
- < 90th
- 90th
- 95th
- 97th

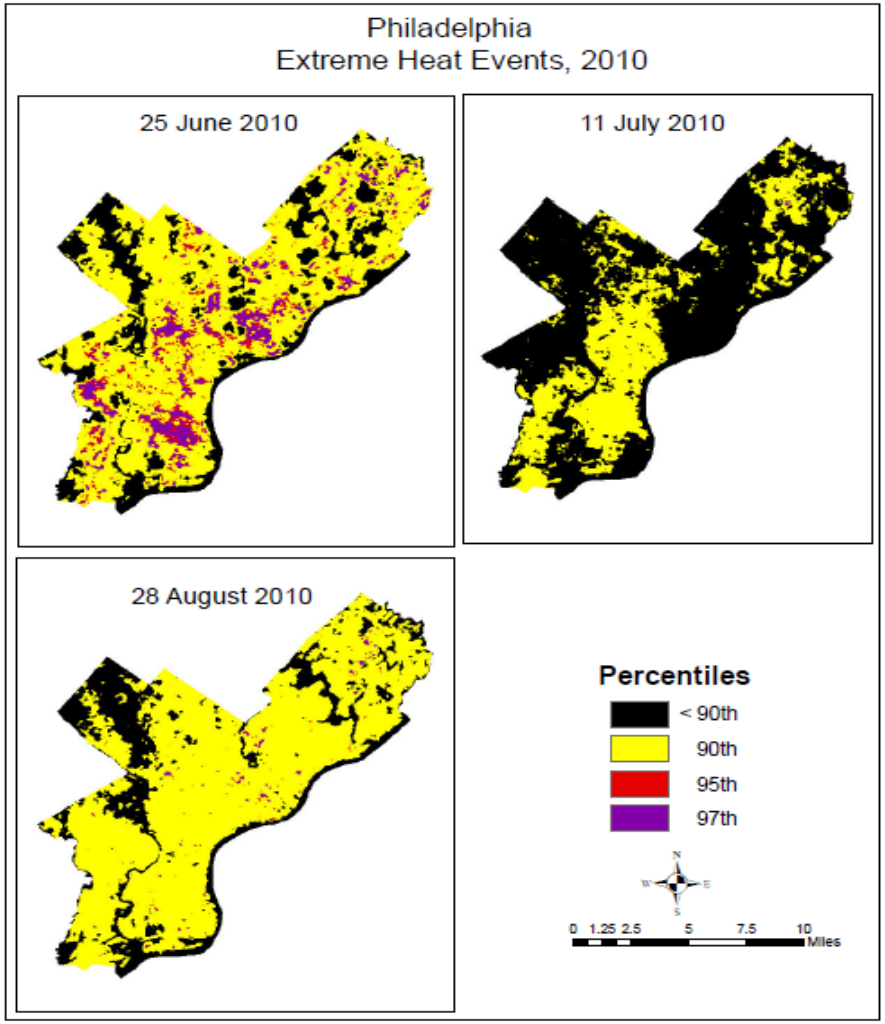
0 1 2 4 6 8 Miles

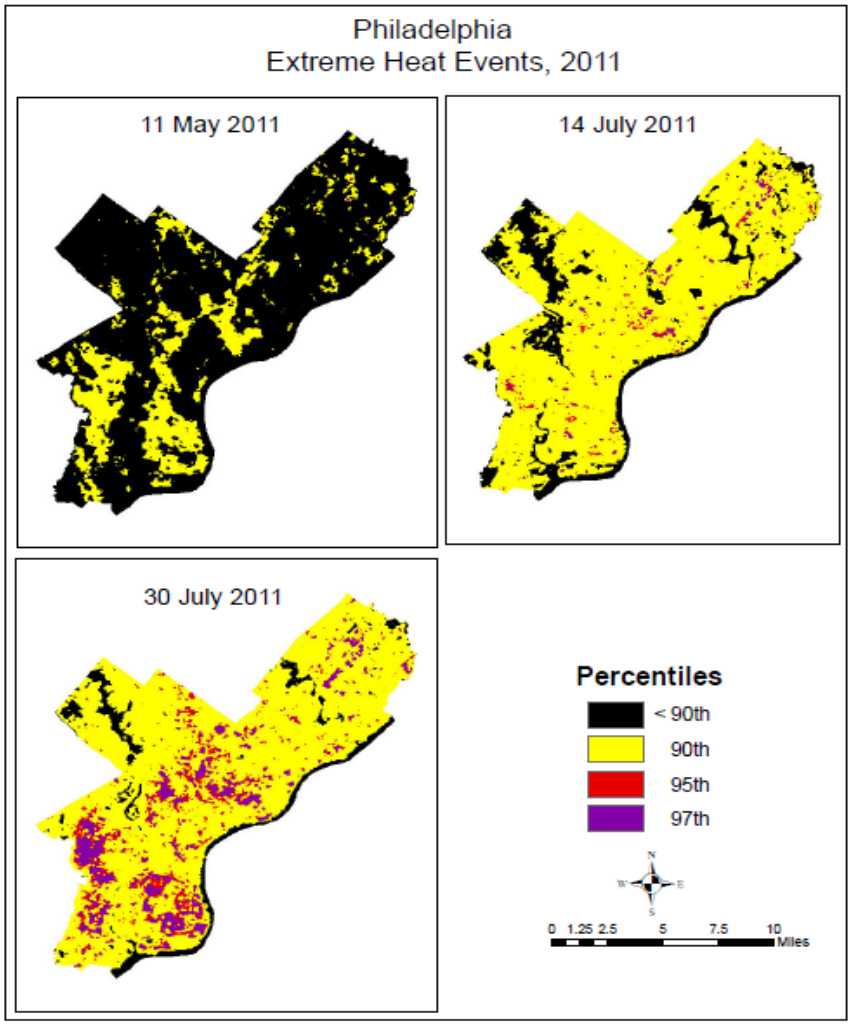
13 June 2011



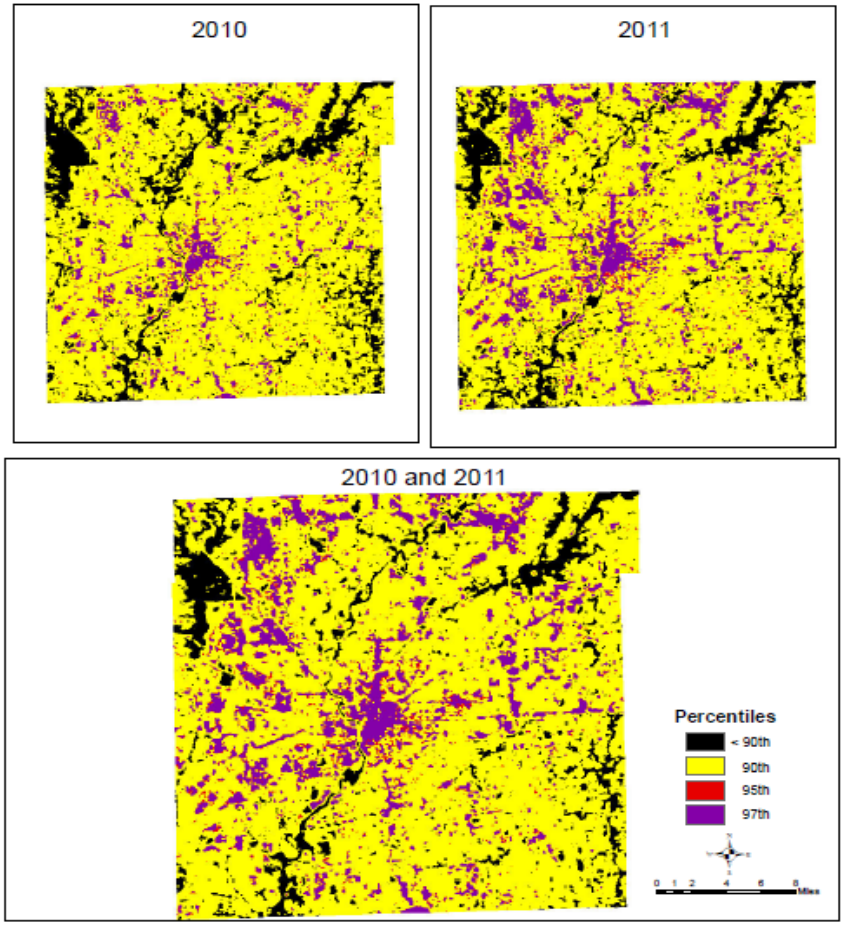
29 June 2011



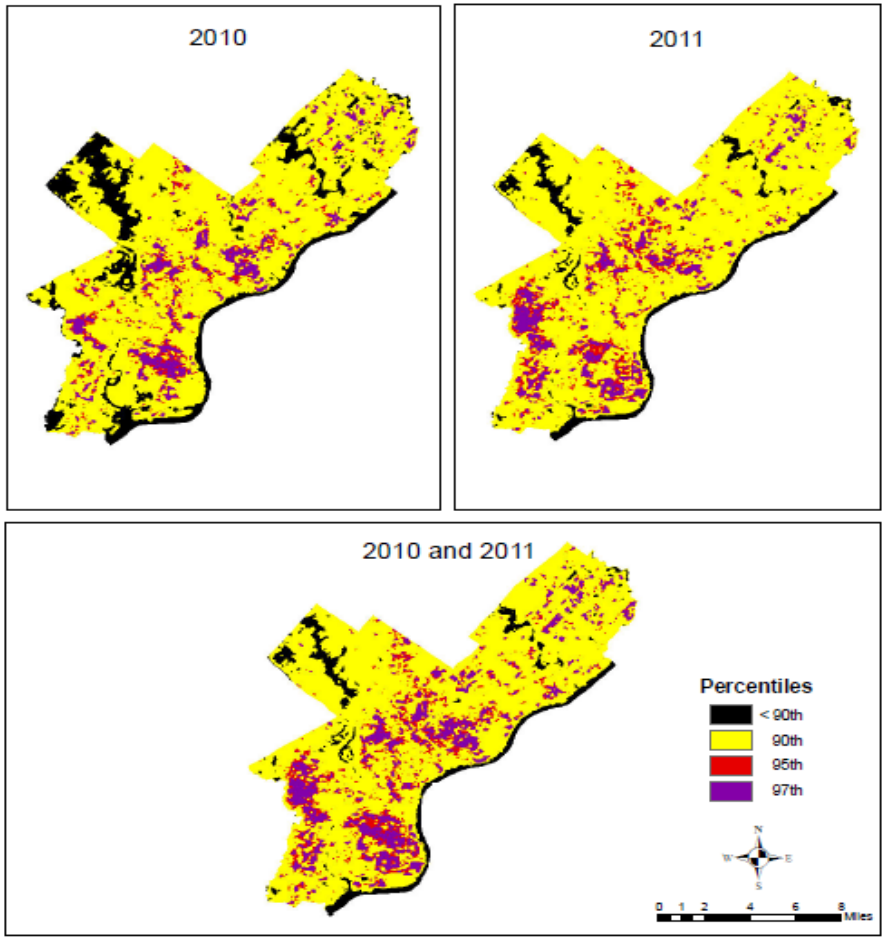

Philadelphia
Extreme Heat Events, 2010
25 June 2010
11 July 2010
28 August 2010
Percentiles
< 90th
90th
95th
97th
0 1.25 2.5 5 7.5 10
Miles


Philadelphia
Extreme Heat Events, 2011
11 May 2011
14 July 2011
30 July 2011
Percentiles
< 90th
90th
95th
97th
0 1.25 2.5 5 7.5 10
Miles

Indianapolis
Extreme Heat Events



Philadelphia
Extreme Heat Events



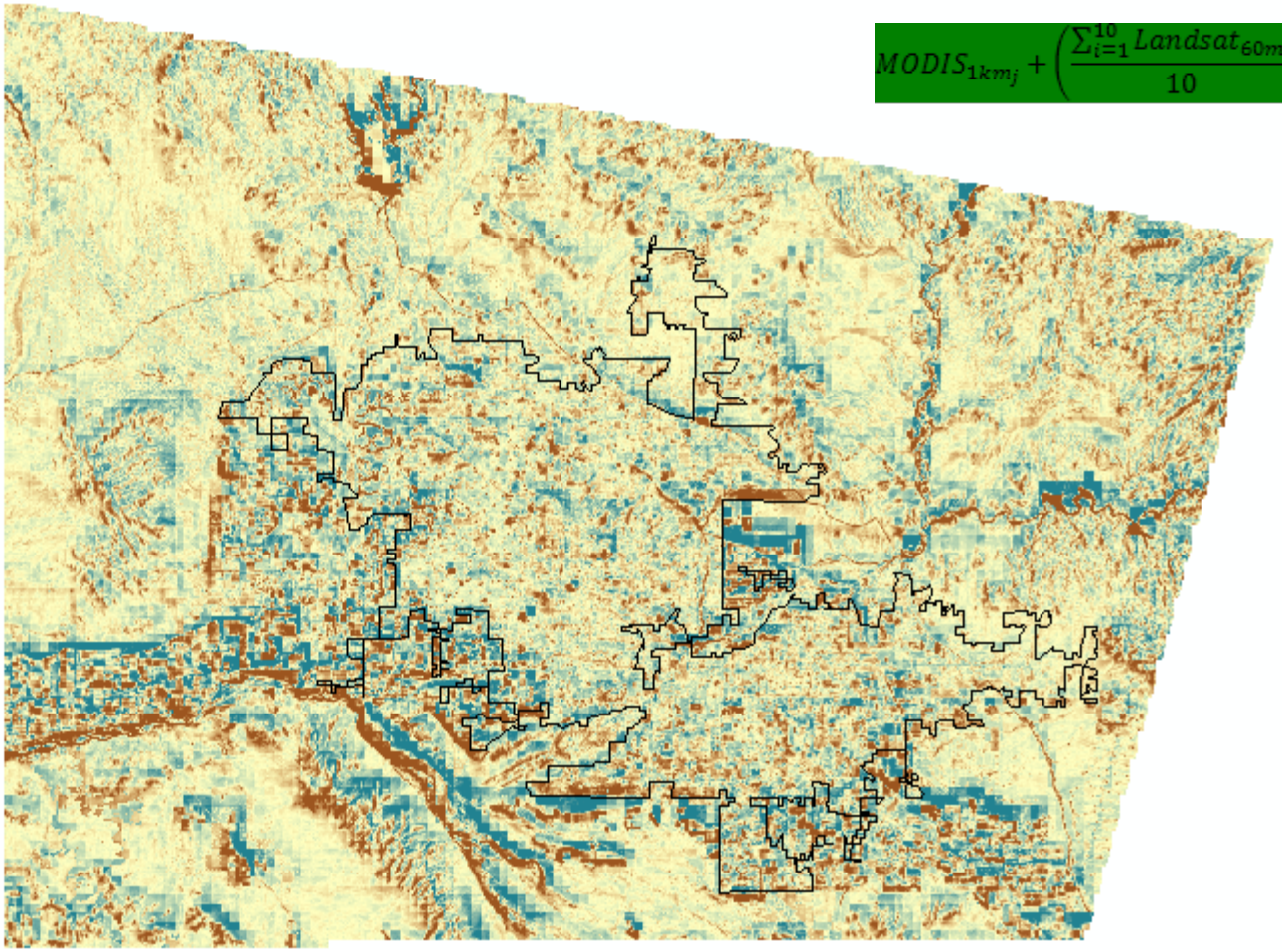
Statistical Normalization Method

*Z*sigma = Temporal Mean Landsat-Spatial Mean Landsat*

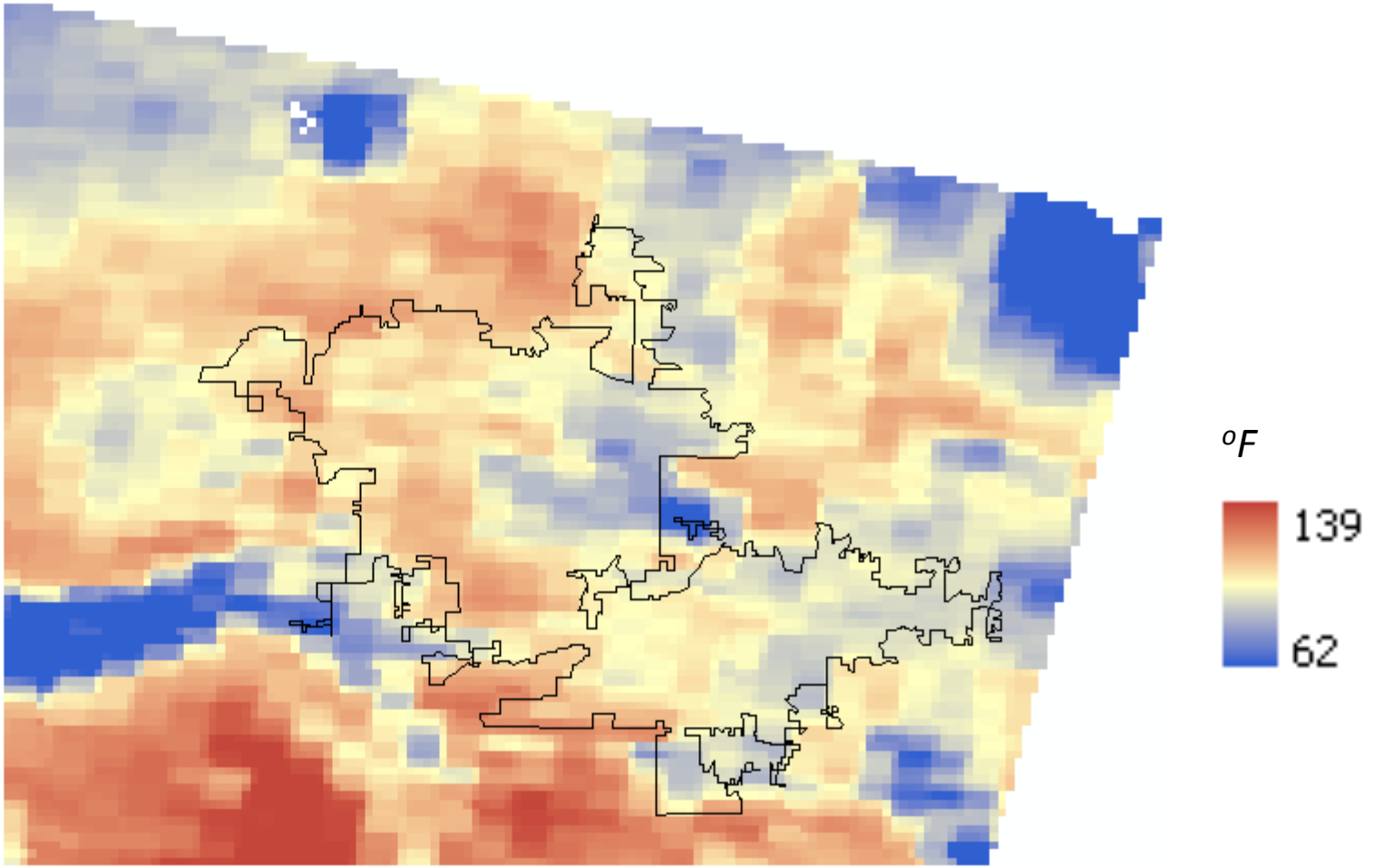
$$\frac{\frac{\sum_{i=1}^{10} Landsat_{60m_i}}{10} - \overline{Landsat_{1km}}}{\sigma_{Landsat_{1km}}} = Z_{60m}$$

$$MODIS_{1km_j} + (Z_{60m} \times \sigma_{Landsat_{1km}}) = MODIS_{60m_j}$$

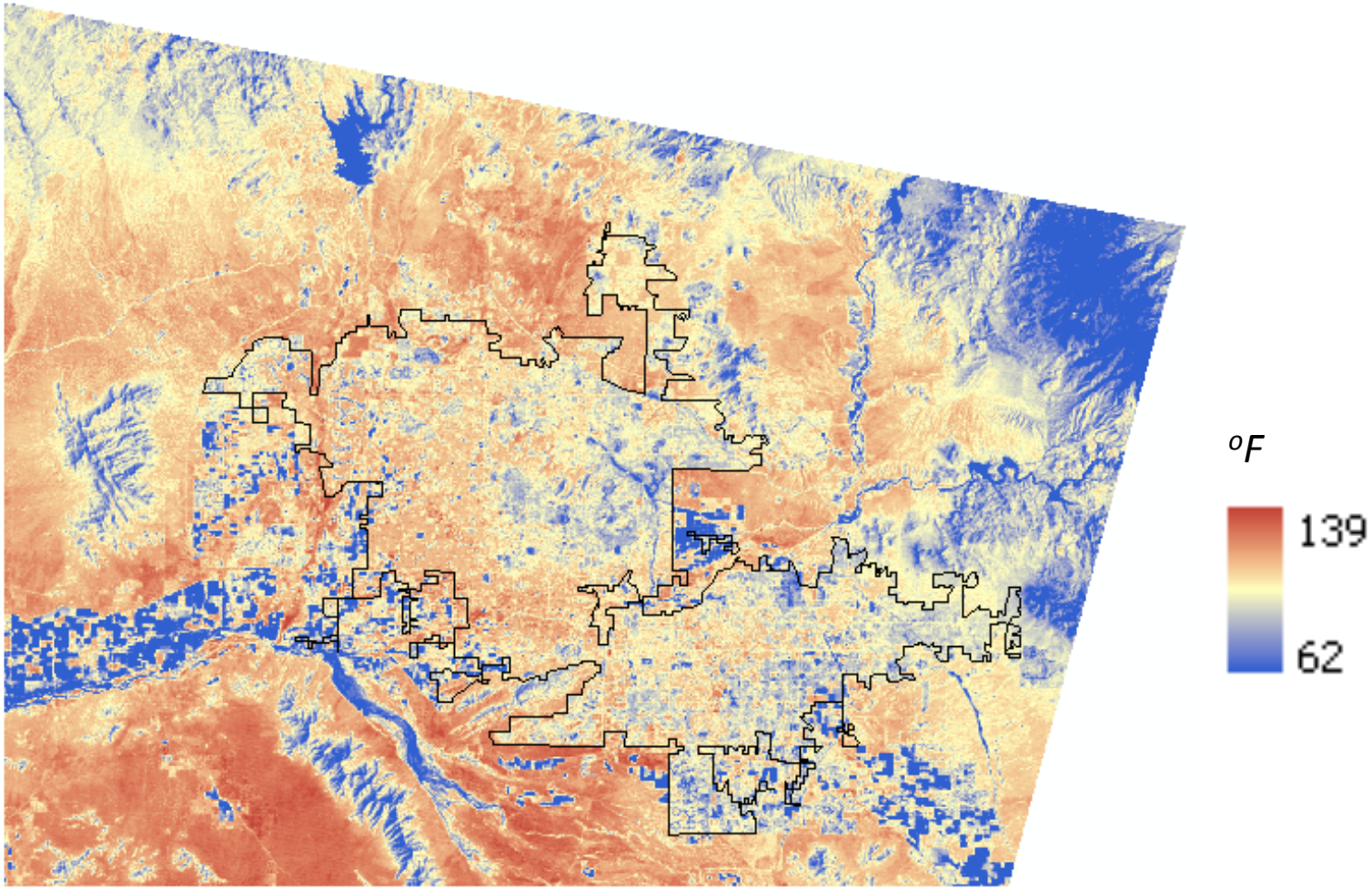
$$MODIS_{1km_j} + \left(\frac{\sum_{i=1}^{10} Landsat_{60m_i}}{10} - \overline{Landsat_{1km}}\right) = MODIS_{60m_j}$$



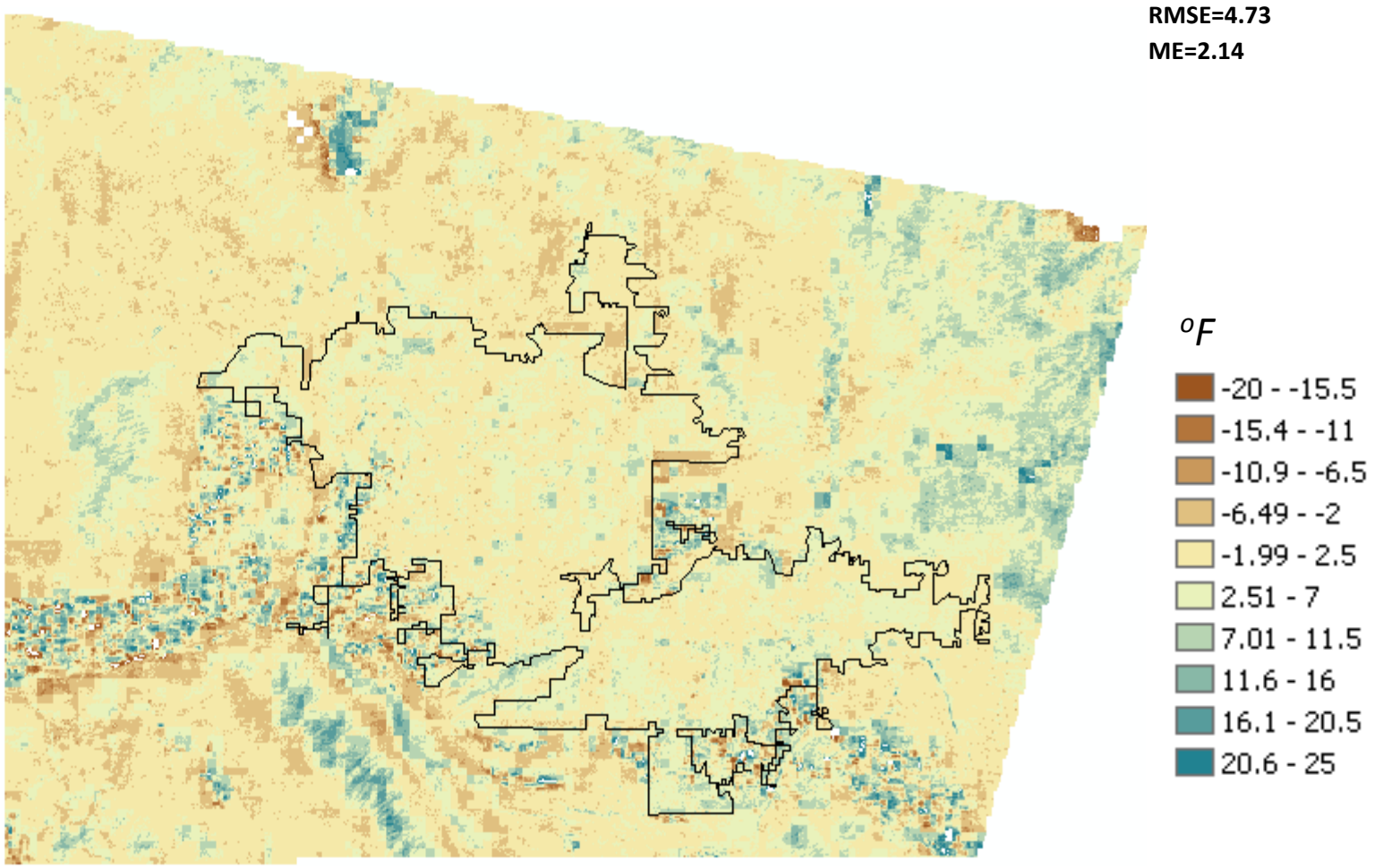
MODIS LST (1 km) (August 28, 2004)



Downscaled MODIS LST (60 m) (August 28, 2004) (Statistical Normalization Method)



Mean Errors (Statistical Normalization Method)



Anticipated Improvement in Emergency Response Capacities

- Improved identification of the “hottest” areas of individual cities and the surrounding municipalities. (Accomplished, for all cities)
- Time-Distance information from central emergency response locations to the most vulnerable areas within a city. *Some cities want this some don’t…* (Dropped from consideration; felt not as importatn)
- Intelligence-led location of cooling centers?-- This has been done in Indianapolis but have had some issues with some city data sharing. (Partially accomplished)

Anticipated Improvement in Emergency Response Capacities

- Improved identification of locations that are particularly vulnerable (Accomplished)
- Improved ability to mitigate the health-related impacts. Especially, when coupled with currently developing heat-health communication toolkits. (In process of coupling with CDCs interfaces) http://www.bt.cdc.gov/disasters/extremeheat/
- Improved communication of events to especially vulnerable individuals/communities---More work is needed here!!!!

Anticipated Sustainability Actions

- Continue working with our current partners and maintain the system for longer duration utilizing funds currently recovered through in-directs or as cities need the system have them help us support it. ($$$ that we can match in time)
- Continue outreach to other cities. We have done this for the top 100 cities in the U.S. and plan to have some discussions to “create” a system for them. Issue right now is “how much will this cost?” Not much of a bearing on this.

Lessons Learned

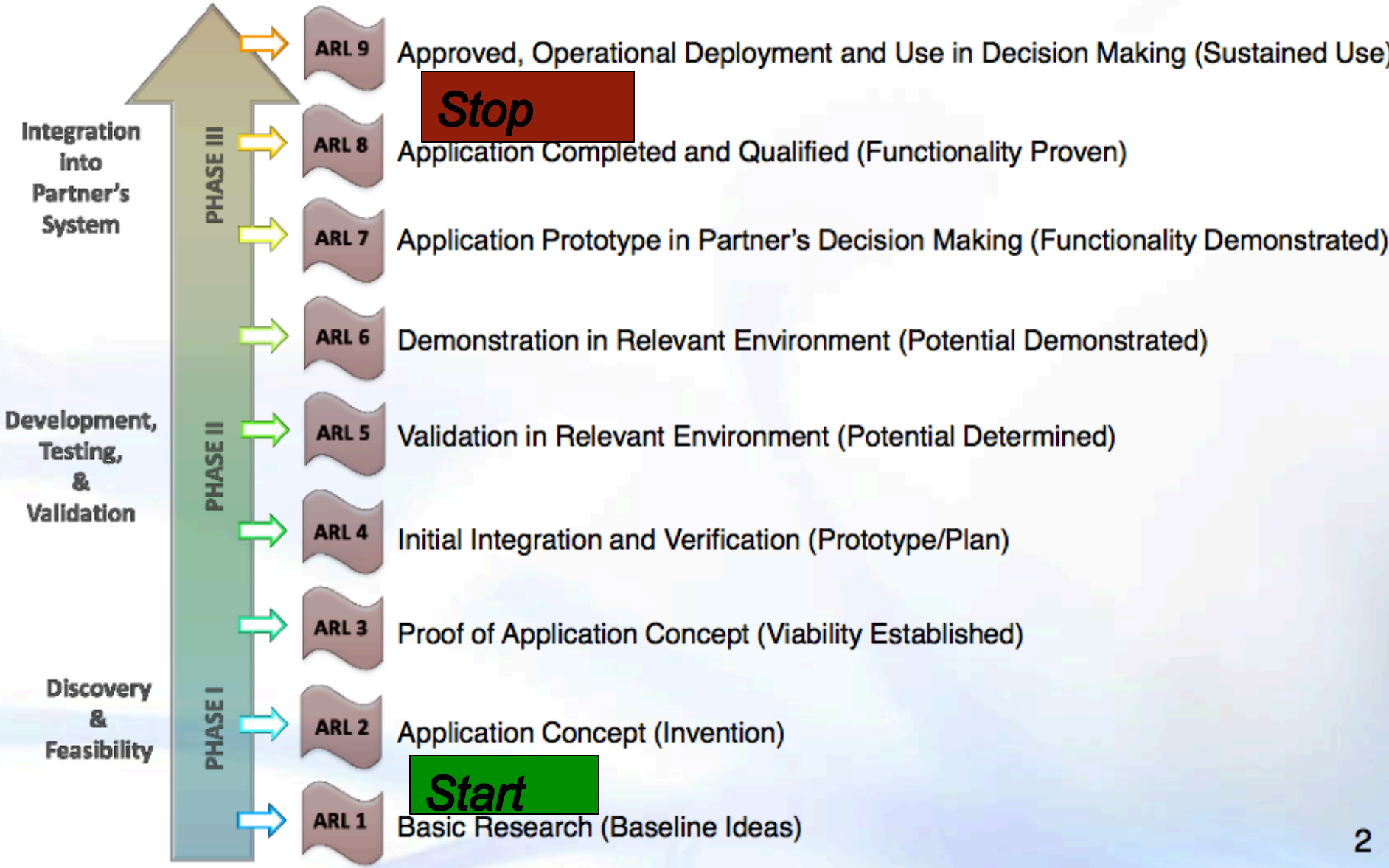
- Some of our cities in this project are heavily constrained by budget considerations. Most seem to like the system but purchasing it is a challenge. We plan to sustain it because we want more data to further work with the models.
- The competing Heat Watch/Warning System model is well recognized but many cities we have contacted outside our current study area think our system is overlap or somehow competitive. They would prefer our system but it is difficulty to find out how Heat Watch/Warning System is getting his support. Seems to be a contract through NOAA/NWS.

Publicity (in addition to research publications)

- Our project has been on FOX and NBC affiliates in Indiana in summer 2010, 2011, 2012. (They found us!!!)
- Live radio interviews
- Multiple newspaper articles
- YouTube interviews

Scholarly Publication

- At least 11 publications are published on this project in the peer-reviewed literature. With several additional manuscripts in development.
- 10 student graduate (MS) theses have been developed on data collected and techniques utilized in this project. Including 3 that are in development.
- 1 Ph.D. dissertation in development (possibly more)


ARL 9
Approved, Operational Deployment and Use in Decision Making (Sustained Use)
Stop
ARL 8
Application Completed and Qualified (Functionality Proven)
ARL 7
Application Prototype in Partner's Decision Making (Functionality Demonstrated)
ARL 6
Demonstration in Relevant Environment (Potential Demonstrated)
ARL 5
Validation in Relevant Environment (Potential Determined)
ARL 4
Initial Integration and Verification (Prototype/Plan)
ARL 3
Proof of Application Concept (Viability Established)
ARL 2
Application Concept (Invention)
Start
ARL 1
Basic Research (Baseline Ideas)
Integration into Partner's System
Development, Testing, & Validation
Discovery & Feasibility
PHASE III
PHASE II
PHASE I

A Special Thanks to My Collaborators

Indiana University:
Dr. Vijay Lulla, Ph.D.
Jeremy Webber, MS Cand.
Austin Stanforth, MS

CDC:
Dr. George Luber, Ph.D.
Natasha Prudent, MPH
Marilyn DeSirios, Ph.D.

NASA Marshall:
Dr. Bill Crosson, Ph.D.
Dr. Dale Quattrochi, Ph.D.
Dr. Mohamad Al-Hamdan, Ph.D.
Sue Estes, MS
Maury Estes, MS
Sarah Hemmings, MS